BFQ790 for 433 MHz Smart Metering Applications

About this document

Scope and purpose

This application note presents a medium power amplifier circuit with Infineon's SiGe bipolar transistor BFQ790 for 433 MHz smart metering appplications.

1. BFQ790 is a 0.5 W reliable and cost effective NPN bipolar transistor, especially for radio frequency (RF) high linearity and high gain amplifier applications.
2. This application note presents the BFQ790 medium power amplifier circuit design and measurement results at 433 MHz.
3. Key performance paramerters achieved:

   Gain = 22.7 dB

   Input return loss = 12.5 dB

   Output return loss =12.5 dB

   Output P1dB = 26.8 dBm

   Output IP3 = 34 dBm.

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1) The graphs are generated with the simulation program AWR Microwave Office®.

1 Introduction

1.1 BFQ790/BFP780 Medium Power Amplifier in Smart Metering Applications

Driven by energy efficiency, traditional electricity meter is experiencing the gradual conversion to smart meter. The smart meter is ``an electronic system that can measure energy consumption, providing more information than a conventional meter, and can transmit and receive data using a form of electronic communication´´ [1]. Smart meter is a key device in a efficient, flexible and intelligent energy distribution network, which provides not only for the utility companies the advanced ability of the energy grid management but also the detailed energy consumption report for the end users.

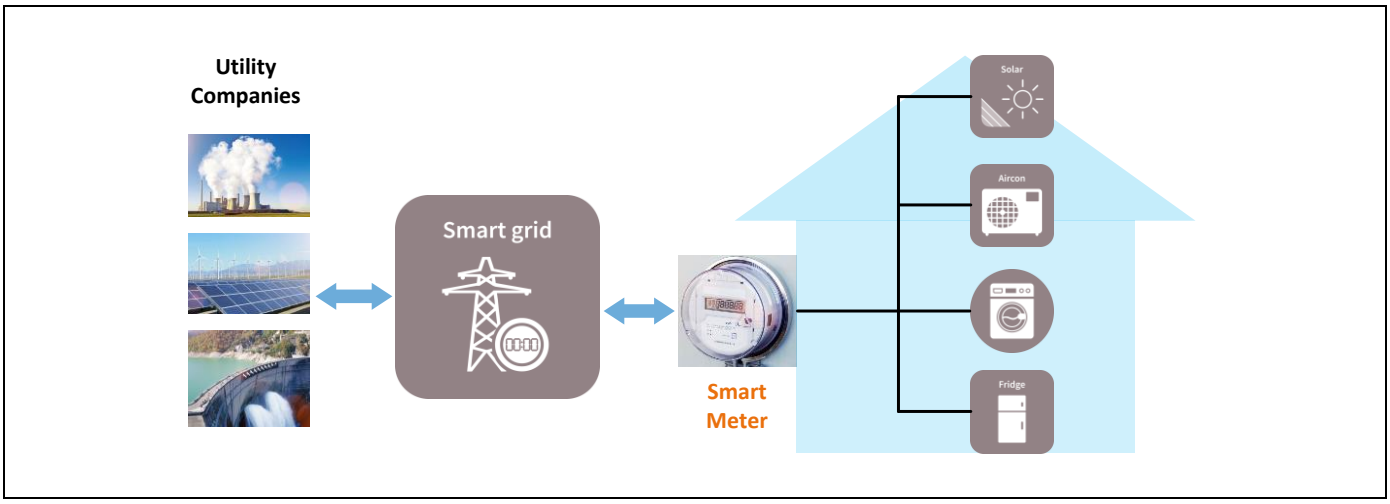

Figure 1 Smart Meter in Power Grid

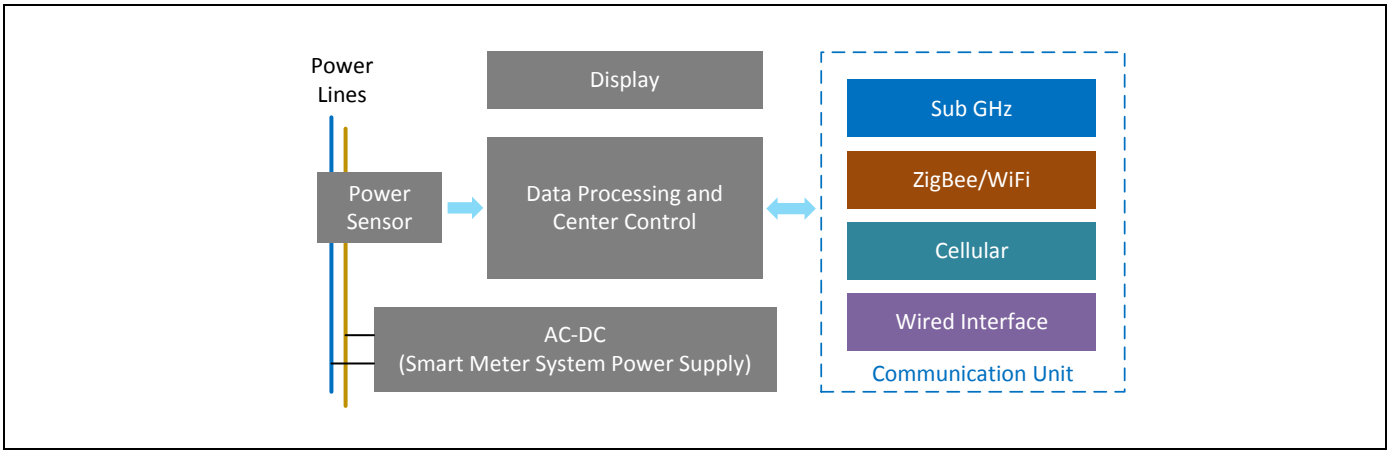

Figure 2 Smart Meter Block Diagram

The communication unit in a smart meter plays important role, since the data communication between smart meters and the power grid should be guaranteed in terms of quality, time, and security. As a result, more than one technology is adopted at the same time to fulfill the requirements. The function block diagram of a smart meter is shown in Figure 2. Among all the communication standards, sub-GHz unit communicates mainly between smart meter and the data collector or concentrator. Sub-GHz wireless

technology, together with low data rate GFSK/GMSK modulation scheme, benefits in long range capability, better sensitivity and lower interference. Owning to the advantages of sub-GHz wireless technology features, the output power of the system is in the medium power range, which is perfectly matched with Infineon medium power transistor specifications. The block diagram of the sub-GHz RF front-end with Infineon medium power amplifier BFQ790/BFP780 is shown in Figure 3.

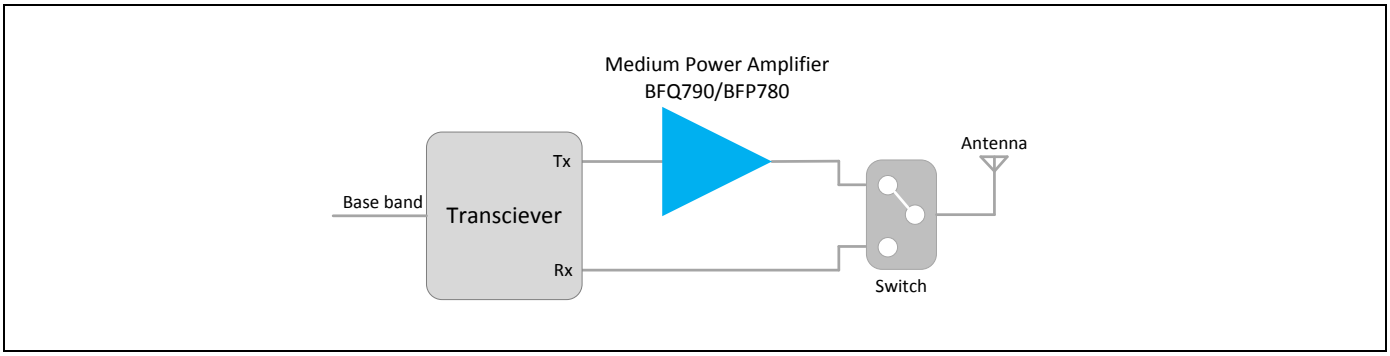

Figure 3 Sub-GHz RF Front-End with Infineon Medium Power Amplifier BFQ790/BFP780

1.2 Infineon Medium Power Transistor Family

BFQ790 and BFP780 are general purpose medium power Radio-Frequency (RF) NPN transistors in Infineon's Silicon Germanium (SiGe) product portfolio for wireless applications. These applications include mobile basestation transceivers, cellular repeaters, the industrial, scientic and medical (ISM) radio band amplifiers, and test equipments. Their operating frequency range can be as high as 3.6 GHz, and the application circuit can be optimized for specific frequency bands with external matching components. The output power level of BFQ790 and BFP780 is 27 dBm and 23 dBm respectively.

BFQ790 is housed in the halogen-free industry-standard package SOT89. The high thermal conductivity of silicon substrate and the low thermal resistance of the package add up to a thermal resistance of only 35 K/W, which leads to moderate junction temperature even at high dissipated power values. The proper die attach with good thermal contact is 100% tested, so that there is minimum variation of thermal properties. The device is based on Infineon's reliable and cost-effective NPN SiGe technology running in high volume. The collector design allows safe operation with 5 V supply voltage. The BFQ790 is very rugged due to the special collector design protecting it from thermal runaway secondary breakdown, which makes BFQ790 rugged when exposed to mismatch at the output. The special design of the emitter/base diode makes BFQ790 robust and allows for high maximum RF input power.

BFQ790 can serve in a single-stage RF amplifier with very high linearity. This application note presents the RF amplifier cirucit of BFQ790 for 433 MHz applications and the measurement results. The BFQ790 amplifier provides a 22.7 dB gain with the 26.8 dBm output 1dB compression point (OP1dB). Besides, in two-tone test with tone spacing of 1 MHz, the output third order intercept point (OIP3) reaches 34 dBm.

BFQ790 for 433 MHz Smart Metering Applications

2 BFQ790 for 433 MHz Smart Metering Applications

2.1 Performance Overview

Device: BFQ790

Application: BFQ790 for 433 MHz Smart Metering Applications

PCB Marking: M130807-89

Table 1 Summary of Measurement Results

Parameter	Symbol	Value	Unit	Comment/Test Condition
Frequency Range	Freq	433	MHz	
DC Voltage	Vcc	5.0	V	
DC Current	Icc	205	mA	
Gain	G	22.7	dB	Loss of input/output line of 0.05 dB are included
Input Return Loss	RLin	12.5	dB	
Output Return Loss	RLout	12.5	dB	
Reverse Isolation	IRev	32.7	dB	
Output P1dB	OP1dB	26.8	dBm	
Output IP3	OIP3	34	dBm	Power @ Input: 14 dBm f1 = 433 MHz, f2 = 434 MHz
Stability	µ1, µ2	> 1	--	Measured up to 10 GHz

BFQ790 for 433 MHz Smart Metering Applications

2.2 Schematics and Bill-of-Materials

The schematic of BFQ790 driver circuit for 433 MHz smart metering is presented in **Figure 4** and its bill-of-materials is shown in **Table 2**.

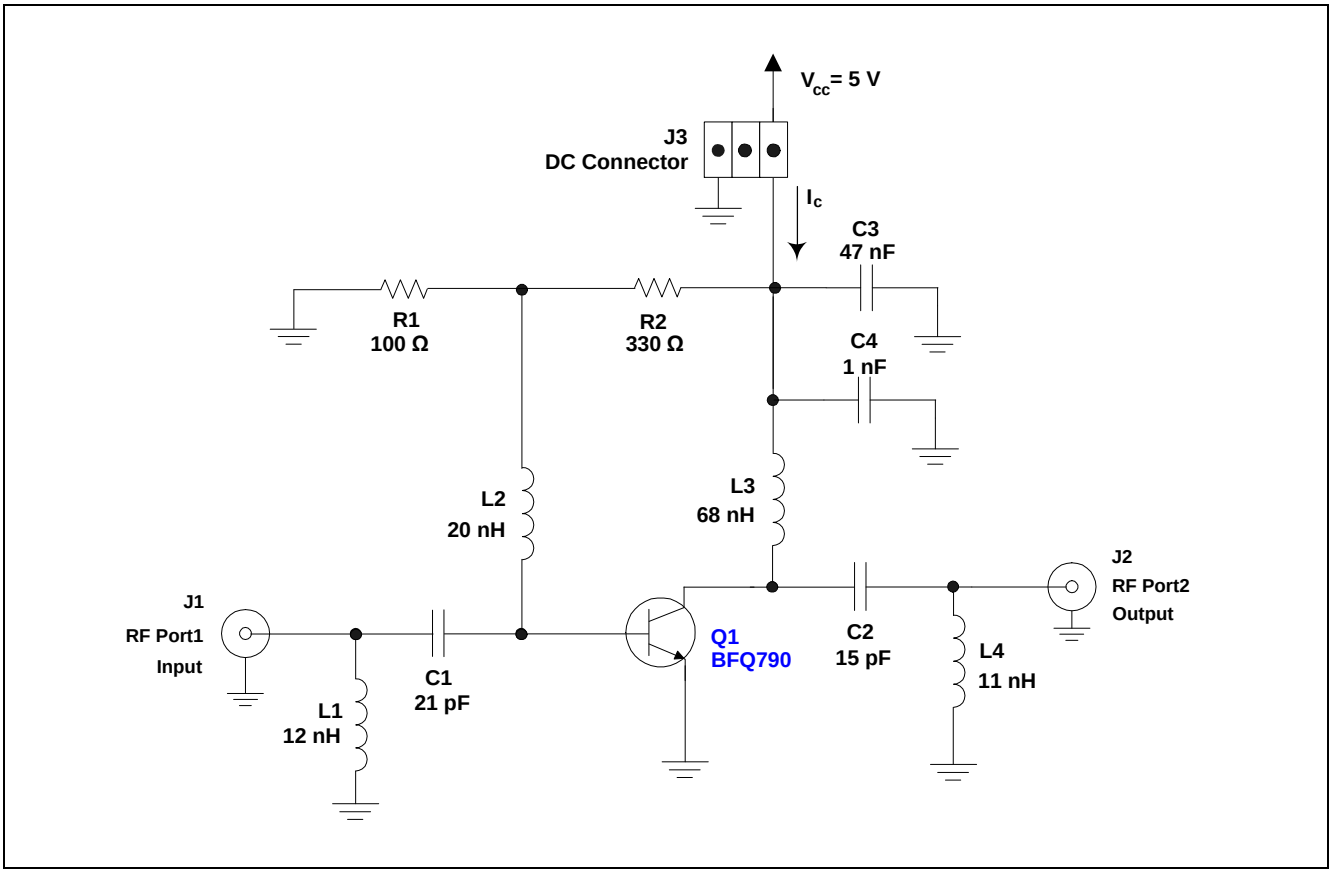

Figure 4 Schematic of the BFQ790 Amplifier Circuit

Table 2 Bill-of-Materials

Symbol	Value	Unit	Size	Manufacturer	Comment
C1	21	pF	0402	Various	Input matching and DC blocking
C2	15	pF	0402	Various	Output matching and DC blocking
C3	47	nF	0402	Various	RF bypass
C4	1	nF	0402	Various	RF bypass
L1	12	nH	0402	Murata LQG	Input matching
L2	20	nH	0603	Murata LQG	RF choke
L3	68	nH	0603	Murata LQG	RF choke
L4	11	nH	0402	Various	Output matching
R1	100	Ω	0402	Various	DC biasing
R2	330	Ω	0402	Various	DC biasing
Q1	BFQ790		SOT89	Infineon	SiGe medium power transistor

3 Measurement Graphs

The performance of the application circuit is presented with the following graphs.

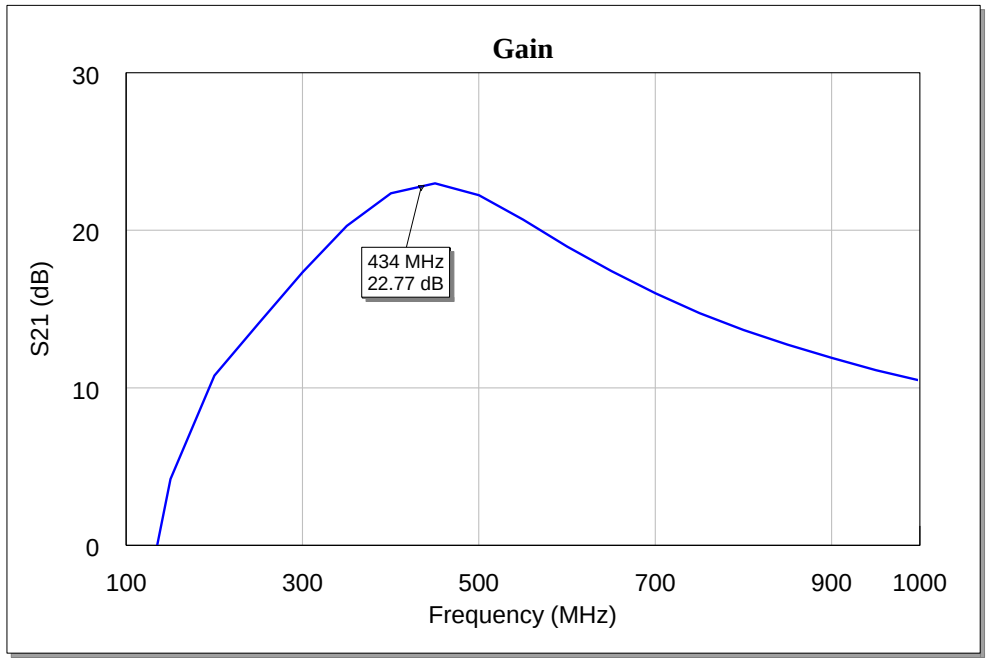

Figure 5 Power Gain of the BFQ790 Amplifier

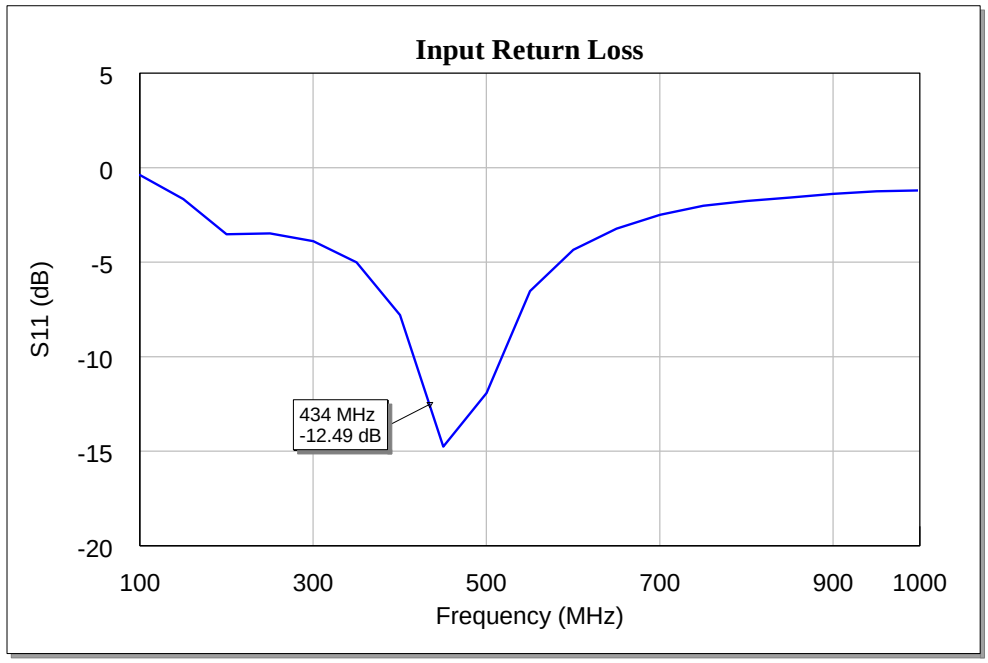

Figure 6 Input Matching of the BFQ790 Amplifier

Measurement Graphs

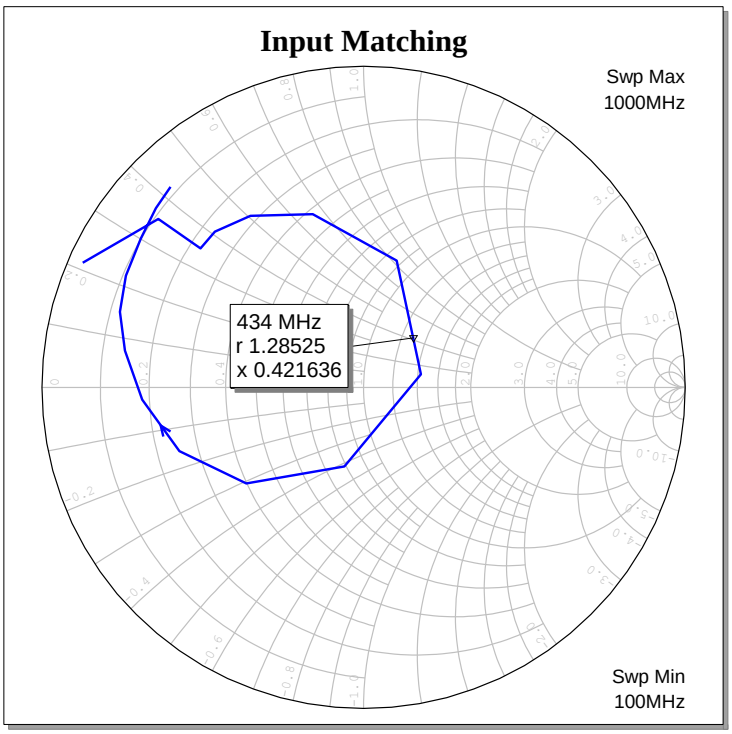

Figure 7 Input Matching of the BFQ790 Amplifier

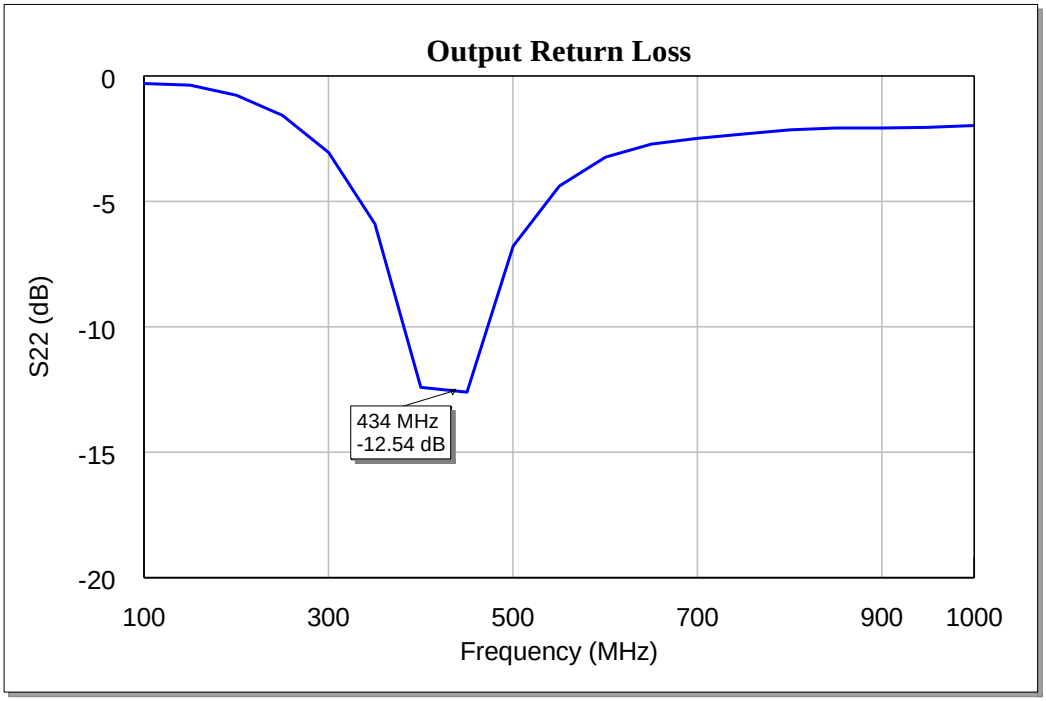

Figure 8 Output Matching of the BFQ790 Amplifier

Measurement Graphs

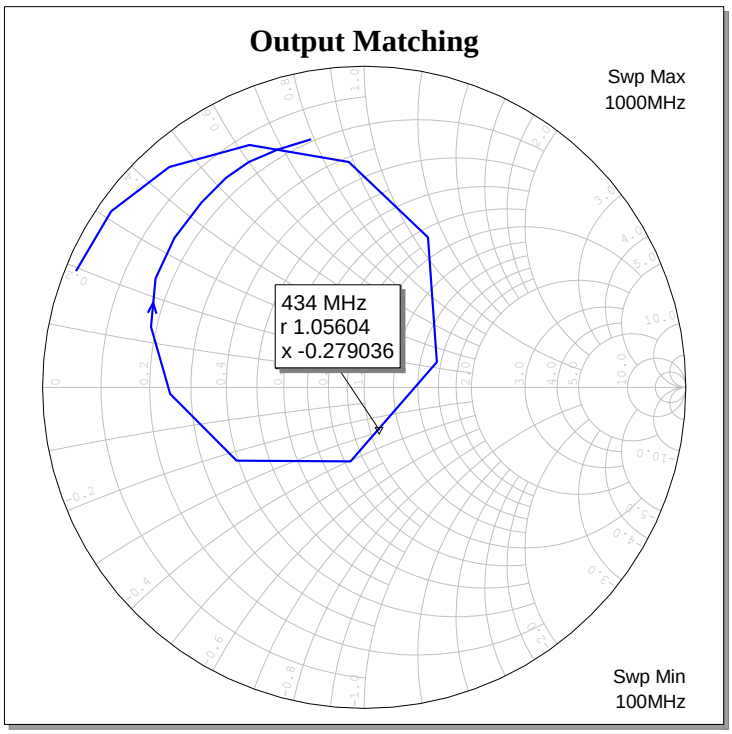

Figure 9 Output Matching of the BFQ790 Amplifier

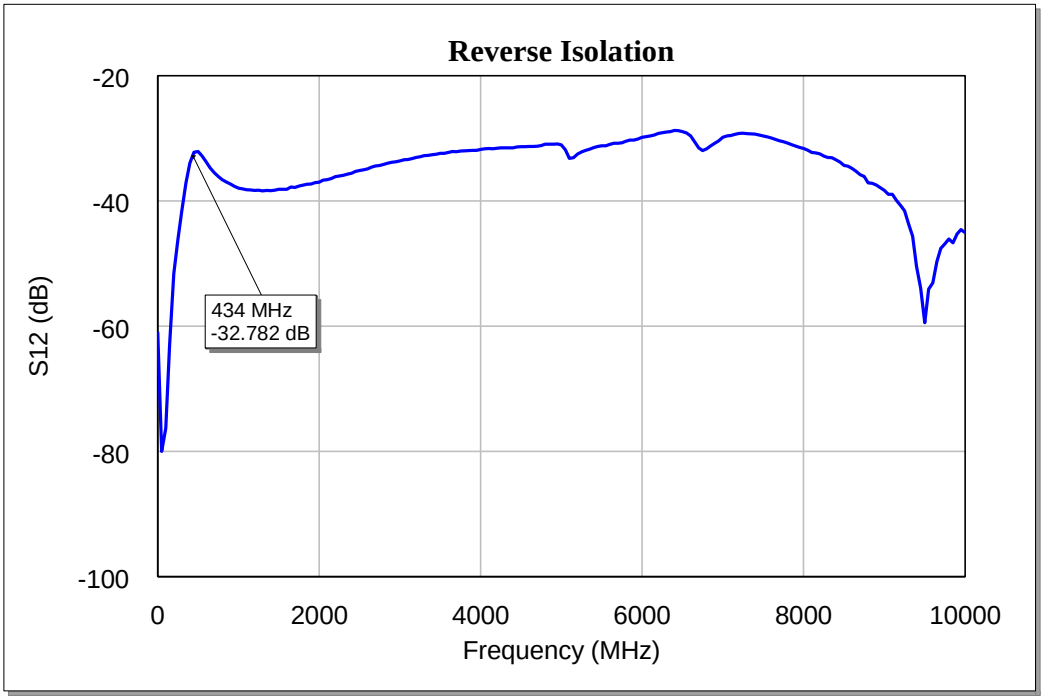

Figure 10 Reverse Isolation of the BFQ790 Amplifier

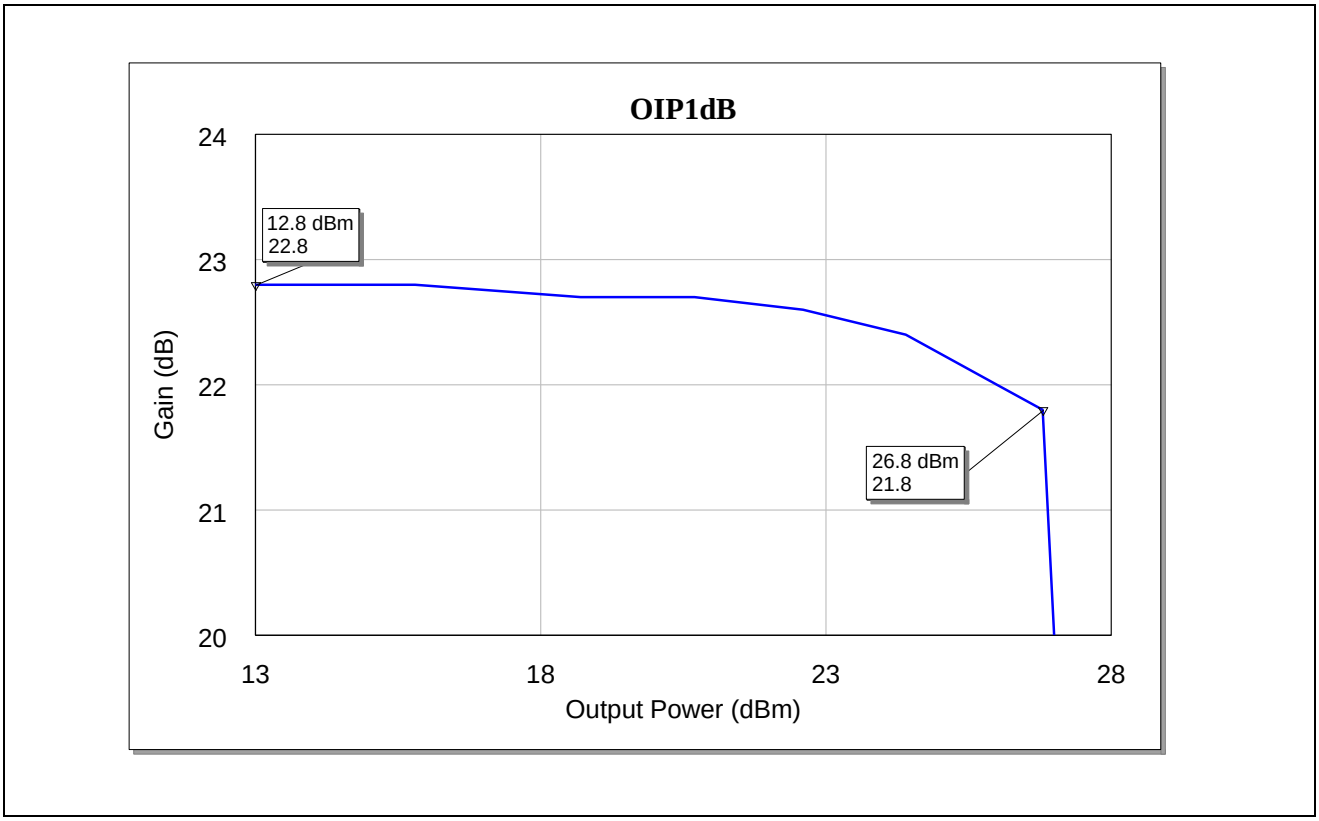

Figure 11 Output 1dB Compression Point of the BFQ790 Amplifier

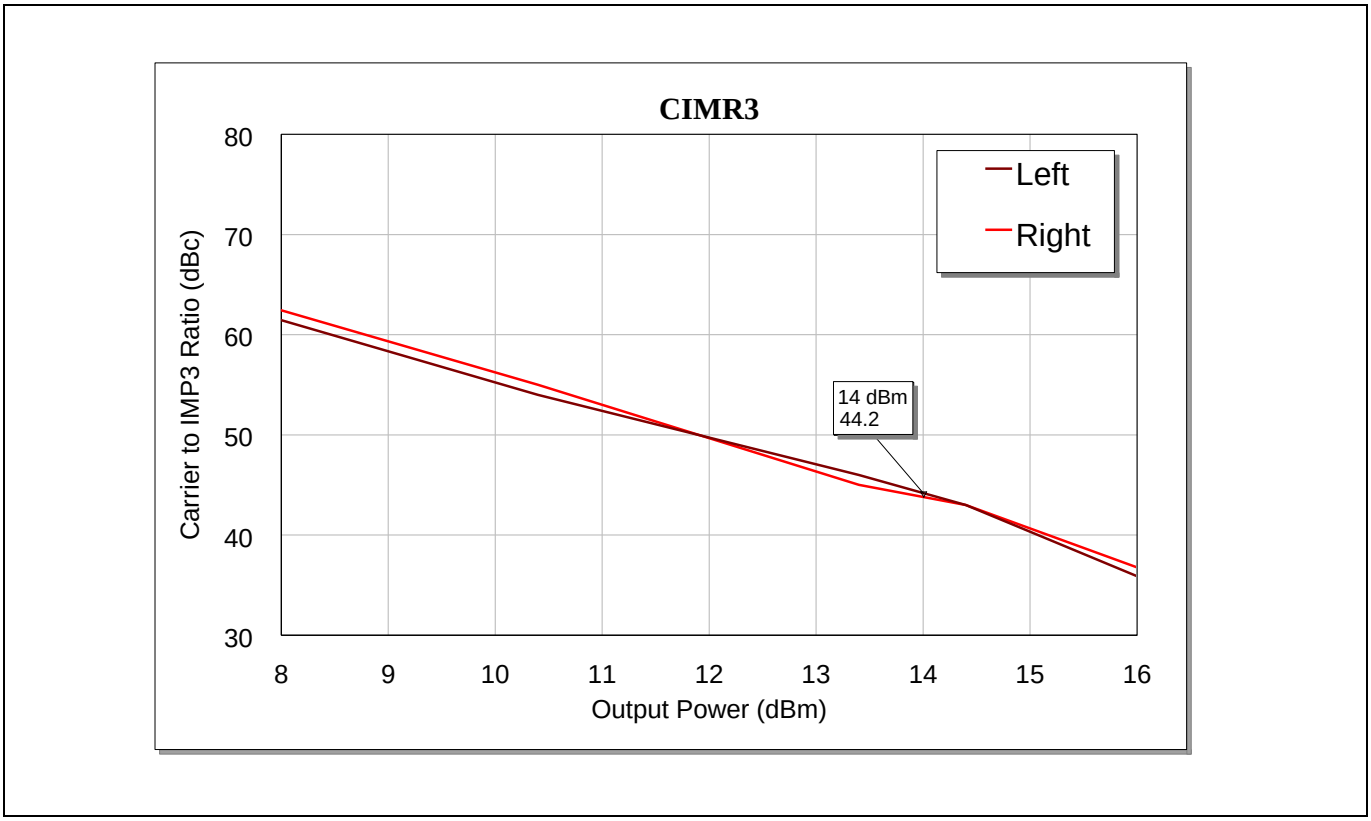

Figure 12 Carrier to IM3 Ratio of the BFQ790 Amplifier

Measurement Graphs

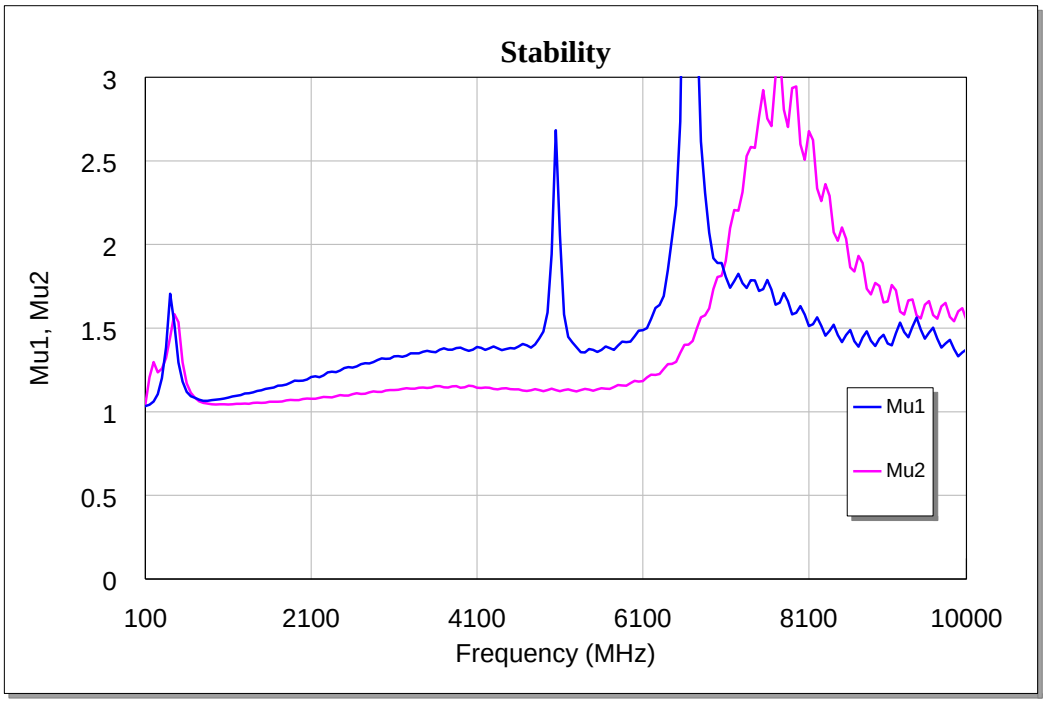

Figure 13 Stability Mu1, Mu2 - factors of the BFQ790 Amplifier

4 Evaluation Board and Layout Information

In this application note, the following PCB is used:

PCB Marking: **M130807-89**

PCB material: **FR4**

ε_r of PCB material: **4.6**

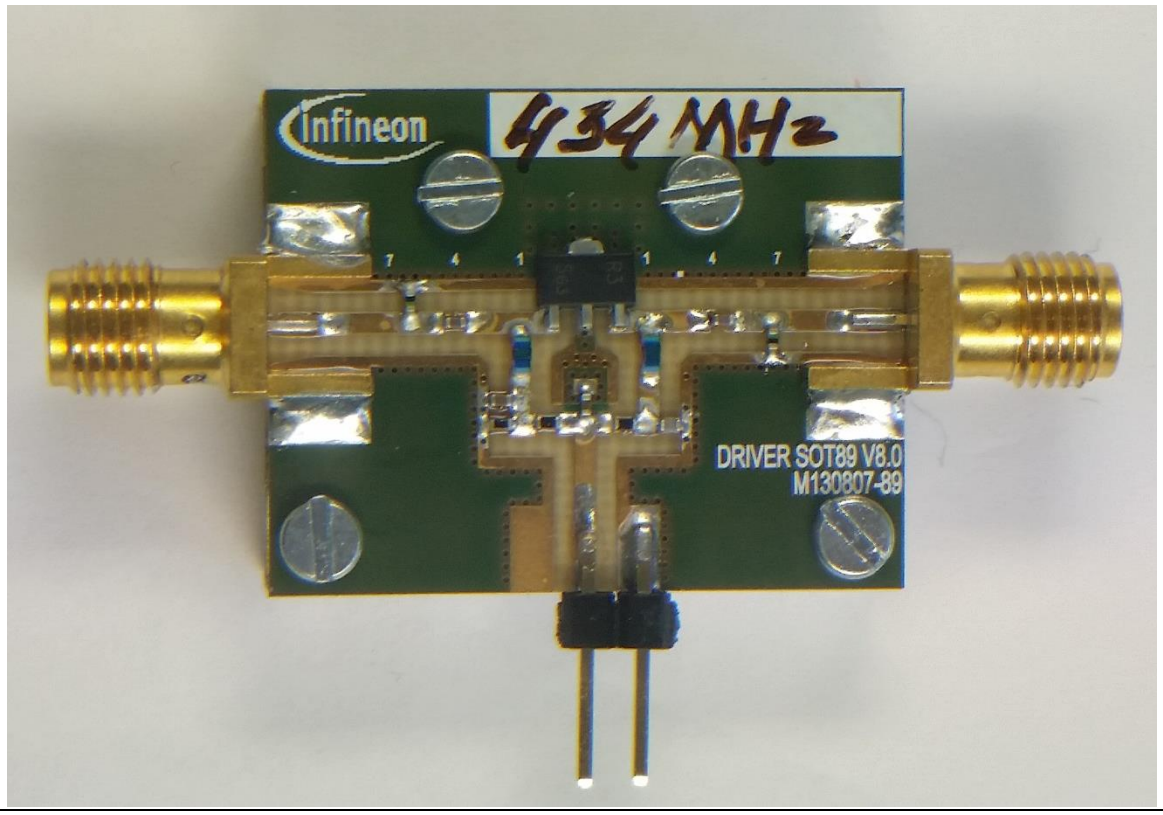

Figure 14 Photo of Evaluation Board (overview)

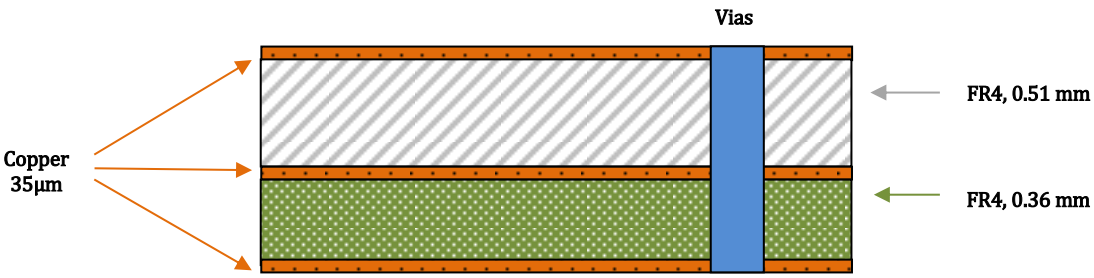

Figure 15 PCB Layer Information

5 Authors

Dr. Olim Hidayov, RF application engineer of business unit “RF and Sensors”.

Dr. Jie Fang, RF application engineer of business unit “RF and Sensors”.

6 Reference

[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, 2012/27/EU. Official Journal of the uropean Union, L315/1. 2012

Revision History

Major changes since the last revision

Page or Reference	Description of change

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